INFLUENCE OF SEVERAL NUTRITIONAL BALANCES ON OLIVE PLANT DEVELOPMENT IN HYDROPONIC COLTURE

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Abstract

Two-year old, selfrooted olive plants (cv. "Frangivento") were grown in sand culture for three years with 7 nutritive solutions,which differed from the relative balances of couples of elements.

Hoagland's solution was utilised as reference. Each thesis consisted in 24 plants, randomly divided in groups of six. Growth and leaves number and blade area were measured; on the central leaves of one year shoots the analysis for N,P,K,Ca and Mg was made at vegetation end (November)

Mineral nutrition proved able to regulate vegetative development, and is at times represented by the nutritional status of leaves.

The complete thesis (thesis 1) induced a good and constant growth; but it was surpassed by thesis 7, which had higher levels of P and was S deficient.

High doses of N are phytotoxic and determined the distal leaf edge necrosis first, and plants death later; its deficiency, ready detectable as N contents in leaves, stops growth.

Particularly rapid and lethal is Ca deficiency, that causes the death of young leaves and apices. The dose of 1 meq of Ca^{++} in nutritive solutions (40 meq) is not sufficient to halt the process when symptoms are evident.

The results of growth and foliar analyses with K and P deficiency on the third year are not clear, and on this subject the research should be perfected.

1. Introduction

The olive is a plant whose cultivation area is limited by thermic requirements (minimum winter temperatures and rest period), but is adaptable to a wide range of soil types and conditions.

The works of Bouat (1964), Hartmann et al. (1966) and of Gonzales (1982) are representative of the many manuring trials, results of foliar diagnostics and requirements interpretations.

In order to obtain more representative information on the mineral nutrients requirements of olive, hydroponics (sand culture) research was carried out by Hartmann and Brown (1953), Gavalas (1973) and Milella and Deidda (1975).

We've chosen the same technique to verify the influence of the various elements deficiency and the effect on development of young self-rooted olive plants.

2. Material and methods

Two- year old olive plants, cv. "Frangivento" were grown in 30 l polyethylene pails with a semiautomatic irrigation system, a modification of that described by Eaton (1963), based on the autocalve principle.

Every couple of pails (each containing three plants) was connected to a single 25 l solution tank placed below.

A timer determined, through an increase of pressure, a 40' daily ascending of the solutions, up to about 2/3 of the medium.

This prevented any light exposure and practically eliminated all losses due to evaporation. The solutions recovery was made by gravity. Two pails (i.e. 6 plants supplied by the same tank) constitued one replication, the replications being 4 for each thesis randomly distributed on 3 hydroponic benches.

2.1. Substrate

The plants were grown in white quartz sand (0,5-1,5 mm diameter), quarried in Germany. The sand was washed in demineralized water to remove all dust and water soluble compounds. The sand analysis gave 98% of SiO_2, of the remaining 2% most was Fe_2O_3 and Al_2O_3; very low amounts of K,Na (ortoclase) and Ca were dected.

2.2. Water source and frequencies of nutrient solutions changes

A repeated use of nutrient solutions causes marked changes in pH and may influence the ratios among the various elements and nutrient factors within the solutions. The solutions were, therefore, frequently changed, usually every 12-14 days in summer, every 21 in winter. The water used during the experiments was obtained, after softening, by inverse osmosis, with variable (10-20 ppm) chlorine residues.

2.3. Composition of nutrient solutions

The basis for our nutrient solutions was solution N I described by Hoagland and Arnon (1950), modified. The solutions' composition in the different theses is detailed in table 1.

2.4. Records

The research was carried out in the course of 3 years (1977-79). The totale shoot lenght of each plant, the number of leaves and the number and lenght of feathers were measured each month. At the end of seasonal growth (end of November), leaves were sampled for analysis (N,P,K,Ca,Mg) and for blade area determination; then the shoots were cut back.

N was detected by autoanalysis, P with photocolorimeter, K with flame photocolorimeter, Ca and Mg with atomic absorbance.

3. Results

3.1. 1977

In table 2 the action of the various nutritive solutions is shown. Thesis 1, complete solution, gives an average growth of cm 262, much lower than that achieved by Thesis 7 (cm 539), that was characterised by an absence of S and by a high dose of P (x5), and also lower than Thesis 2 (cm 335), that had a double dose of N. Theses 4,5 and 6 show a lower or similar final growth (cm 162, 198, 151 respectively) if compared to 1; in these there is an absence of K, P and Ca, respectively; for thesis 6 it is worth remarking the appearance, starting from July, or grave symptoms of lack, with necrosis of young leaves and apices. Thesis 3 (lack cf N) only grows cm 34.

In order to compare both nutrient solutions and growth with the nutritional status of plants (foliar analysis), the scheme proposed by Troncoso and Cerda (1982) was utilised; it refers to the analytical data of those plants that show the best vegetative development, in this case those of Thesis 7. A comparison between the latter and n. 1 puts into evidence the similarity of the N,K and Ca values, the second having lower P and Mg levels, but still above deficiency.

The nutritional status of Thesis 2 shows a higher N content, in accordance withe the higher availability of this element. The values of other elements are similar to n. 1, with the exeception of P, which is higher in the occurrence of a bigger availability of N.

The comparison between Theses 7 and 4 points out the low foliar K content in plants grown in the absence of this element, as well as a remarkable increase of Ca, when this nutrient is supplied in bigger quantities. It proves a lack of balance in the Ca/k ratio. Thesis 5 involves low N levels though if far from a deficiency situation; Mg is slightly below the optimum, while K and Ca are at normal values.

Thesis 3 shows extremely low N levels, as was to be expected from the absence of such nutrient from the solution; the values of P,K and Mg are lower than in thesis 1, which has the same supplies; from this it can be inferred that N deficiency obstacles the absorption of these elements.

The comparison between Theses 7 and 6 shows a marked unbalance of the latter towards the binary relationship Ca/K.

3.2. 1978

The results of this year of tests are listed in table 3. It is worth reminding the fact that in the course of this vegetative cycle, in order to keep alive the plants in nutritive solutions n.3,4,5,6 and 7, they were supplied with the elements missing in 1977, at 1/10 of the concentration of the complete solution.

Development and foliar values of the various situations are therefore more uniform if compared to the year before.

As regards to growth, Thesis 7 shows the best vegetative development, superior to that of the complete solution (N 1 Hoagland), wich remained on the levels of the previous year.

Thesis 2 shows instead a sensible reduction of growth, thus pointing out how the exces of N starts exerting a negative action; such an effect is also put into evidence by considerable necrotic areas that appear in the distal half of mature leaves.

The growth quantity of Theses 3,4 and 5 increases if compared to that of the previous year; it might be due to the supply of little quantities of the tested elements.

The growth values appear greatly compromised only in Thesis 6, in spite of the addition of 1 meq Ca^{++} to the nutritive solution.

The levels of individual nutrients in leaves are fairly similar, with the exception of the thesis involving a high supply of N, in wich the values of this element are very high, and of the thesis K-deficient, in which appears a low content of this element in leaves, together with an increase of Ca.

From these results it is evident how, with the exception of Ca, limited supplies of nutrients after a situation of strong deficiency rapidly influence both vegetative development and nutrients content in leaves. This same thesis and 7 show the same high quantity of P, as in the year before.

3.3. 1979

The data collected in 1979 are summarised in table 4. In that year the nutritive solutions were brought back to 1977 values.

As to growth values, Thesis 7 confirms a bigger vegetative stimulus. Thesis 1 keeps constant in the three years its growth rhythms n. 4 and 5 are not much different from the complete solution, while growth is seriously reduced when N is deficient (Thesis 3).

Both N excess and Ca deficiency caused the death of plants; nitrogen toxicity and calcium deficiency appear from our work as the most dangerous nutritional phytopaties.

From an analytical point of view, the N and P content of the different theses is similar to that found in 1977, with Thesis 3 showing again low N levels, which goes with the lack of this nutrient in the nutritive solution and with the poor growth.

In all considered theses we generally found high levels of K and low levels of Ca, if compared to 1977 data, this giving rise to an unbalanced binary relationship in favour of K. This last finding cannot be adequately explained and deserves further research, although Thesis 4 maintains on the 1977 tendency.

In the table 5 are shown the indexes of growth and foliar surface on the different years; a strict relation ship (R= 0,962) appears evident between the two indexes. The action of nutritive solutions on foliar surface is consequently similar to that on plant growth.

4. Discussion

Thesis 1 (N 1 Hoagland) is adequately suitable to the study of nutritional requirements of olive, and for three years running plants have grown at constant quantities of vegetation. Nevertheless, it doesn't probably reflect the best nutritional situation for this species. Actually, if we take thesis 1 elongation as a reference point (table 5), we can see that Thesis 7 has a development 1.63 times bigger, while Thesis 2, with a double dose of N, does not develop more than n. 1 in its two years of life, its main peculiar feature being only wilder leaf blades.

The role of P in olive manuring or the relative P/S balance come up again. The N deficiency, put into evidence also by foliar analysis, stops plant growth, but relatively low doses (low relative concentration but constant supply) allow an acceptable growth; in this case even the foliar analysis values do not appear particularly low for this element. Its excess (N x 2) provokes such a phytotoxicity as to kill the plants.

Ca deficiency proved to be particularly dangerous, as it prevents the growth stoppage in case of lack of adequate nutritional support. Even low doses (1 Meq of Ca^{++}) do not appear able to prevent the dieback of both apices and young leaves in cv. "Frangivento" grown in such conditions.

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Table 1 - Composition of nutritive solutions (meq) supplied in the years 1977-1978*1979.

Ions \ Solutions		1	2	3	4	5	6	7
Total	meq	40	47.5	40	40	40	40	40
NO_3^-	"	15	22.5	0	15	15	15	15
$H_2PO_4^-$	"	1	1.0	1	1	0	1	5
Cl^-	"	0	0.0	15	0	0	0	0
SO_4^{--}	"	4	4.0	4	4	5	4	0
K^+	"	6	6.0	6	0	6	16	6
NH_4^+	"	0	7.5	0	0	0	0	0
Ca^{++}	"	10	10.0	10	16	10	0	10
Mg^{++}	"	4	4.0	4	4	4	4	4

Micronutrients = Hoagland with Fe^{++} EDTA

* In 1978 to theses 3 (-N), 4 (-K), 5 (-P), 6 (-Ca), 7 (S-8) the missing element was given in concentrations equivalent to 1/10 of those of thesis 1.

Tabel 2 - Values of growth and foliar analysis at the end of 1977 vegetative season.

Theses	Growth (cm)		Foliar analysis (% DM)				
			N	P	K	Ca	Mg
1	262,5	cd	1.95	0.134	1.85	0.78	0.12
2	335.6	d	2.72	0.187	1.71	0.73	0.10
3	34.4	a	0.79	0.113	1.20	0.83	0.09
4	163.1	b	1.86	0.132	0.63	1.52	0.17
5	198.9	bc	1.57	0.084	1.81	0.86	0.11
6	151.7	b	1.81	0.126	2.67	0.53	0.08
7	520.9	e	2.16	0.291	1.99	0.79	0.18

Table 3 - Values of growth and of foliar analysis at the end of 1978 vegetative season.

Theses	Growth (cm)		Foliar analisis (% DM)				
			N	P	K	Ca	Mg
1	346.9	c	1.70	0.13	2.28	0.92	0.12
2	235.7	b	2.87	0.20	2.81	0.64	0.12
3	166.9	ab	1.83	0.12	2.00	0.75	0.16
4	259.4	bc	1.92	0.15	1.77	1.30	0.17
5	215.8	b	1.73	0.13	2.27	0.98	0.14
6	93.5	a	1.97	0.15	2.82	0.85	0.14
7	459.6	d	1.93	0.18	2.42	0.87	0.18

Table 4 - Values of growth and of foliar analysis at the end of 1979 vegetative season.

Theses	Growth (cm)		Foliar analysis (% DM)				
			N	P	K	Ca	Mg
1	396.8	b	2.00	0.17	2.4	0.50	0.20
2	-	-	-	-	-	-	-
3	109.4	a	1.10	0.20	2.6	0.45	0.14
4	300.1	ab	2.10	0.19	1.7	0.90	0.20
5	398.7	b	1.97	0.20	2.7	0.60	0.20
6	-	-	-	-	-	-	-
7	636.4	c	2.15	0.30	3.2	0.45	0.21

Table 5 - Growth index and assimilating surface index of plants grown in different nutritive solutions. (3 years average)

Theses	Growth index	Assimilating surface index
1	1	1
2	0.98 *	1.14 *
3	0.30	0.32
4	0.71	0.56
5	0.79	0.56
6	0.30 *	0.31 *
7	1.63	1.55
	R = 0.962	

* 2 year average